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SMT Component Reliability for RF Applications

The EMPF recently characterized the reliability of surface mount RF components. The RF frequency band of interest was the X band (10.7 to 11.7GHz). A two pronged test for reliability of circuit card assemblies (CCA) was designed for both extreme thermal cycling and vibration. The rapid thermal cycling and extreme vibration testing simulates the total stress encountered by the assembly over the life of the product but accomplishes it in a relatively short period of time. In order to perform the reliability testing, a test vehicle consisting of a printed circuit board with test structures and components, was designed, fabricated, and assembled at the EMPF.

Surface mount technology (SMT) components were selected that are both commonly used and have operating ranges up to the X band of the RF spectrum. A digital attenuator in a quad flat pack, no lead (QFN) package was used with supporting chip components in 0402 and 0603 sizes. Two surface mount hybrid couplers with different leads were installed, one with L leads and one with castellated leads. Side launch SMA connectors with through-hole ground connections were installed to allow connection to the spectrum analyzer.

The frequency range of the attenuator is up to 13GHz while the other RF components are less than 4GHz based on their application in the actual circuit.

CCA Design and Assembly

The test vehicle was designed to simulate a proposed board stackup and allow the mounting of the SMT RF components. Each board has six RF paths that pass through the components (Figure 1-1). To observe any effects of vibration and thermal cycling on the laminated board, three RF paths were designed with no components to act as controls.

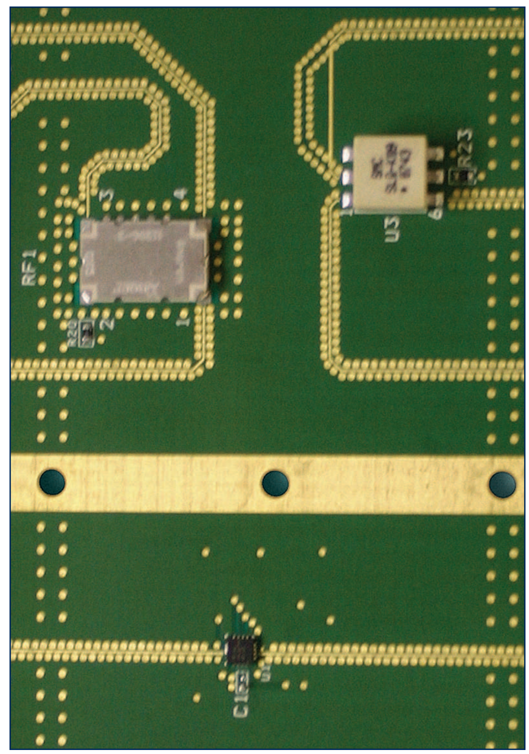

Figure 1-1: Section of test vehicle with digital attenuator and couplers.

The component manufacturer's data sheets were used to define the shapes and sizes of both the pads on the CCA and the cutouts for the solder paste stencil. The stencil thickness was 0.005" to allow the proper solder volume on the 0402 and 0603 chip component ends. The larger, castellated lead coupler required a stencil having a "window pane" feature to reduce the volume of solder used to solder the large center ground to the ground plane.

The solder paste selected is the type typically used for military assemblies (63/37 tin-lead solder with a no clean flux and a J-STD-004 classification of

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Report Documentation Page

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14. ABSTRACT

The EMPF recently characterized the reliability of surface mount RF components. The RF frequency band of interest was the X band (10.7 to 11.7GHz). A two pronged test for reliability of circuit card assemblies (CCA) was designed for both extreme thermal cycling and vibration. The rapid thermal cycling and extreme vibration testing simulates the total stress encountered by the assembly over the life of the product but accomplishes it in a relatively short period of time. In order to perform the reliability testing, a test vehicle consisting of a printed circuit board with test structures and components, was designed,fabricated, and assembled at the EMPF.

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Ask the EMPF Helpline!

Diminishing Manufacturing Sources Material Shortages

Recently, a client called the EMPF Helpline to get information on DMSMS and ruggedization of electronics.

Diminishing Manufacturing Sources Material Shortages (DMSMS) is defined as the loss or impending loss of manufacturers of items, suppliers of items, or raw materials. DMSMS and obsolescence are terms that are often used interchangeably. However, obsolescence refers to a lack of availability due to statutory and process changes, as well as new designs; whereas DMSMS is a lack of sources or materials.[1]

The Defense Standardization Program Office source has addressed the topic by publishing a guidebook that is available for downloading. The guidebook (SD-22) contains Best Practices and tools for implementing a DMSMS Management Program (Figure 2-1). There are many other formal programs offered by the DoD to deal with DMSMS and are available on the internet at the DMSMS Knowledge Sharing Portal at www.dmsms.org and other sites.

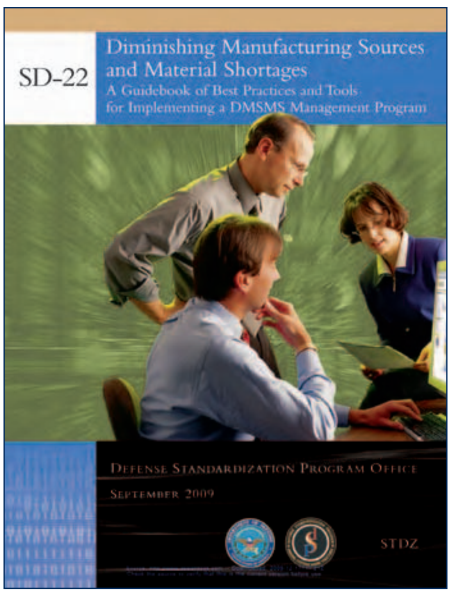

Figure 2-1: A guidebook on DMSMS is available for downloading.

Military requirements for improvements in capability and speed for information handling electronics have increased identically to the commercial consumer's desires and needs. However, the physical endurance requirements remain as stringent and in some cases more severe. Even though the availability of mil-spec electronics has dwindled and the cost has grown exponentially, the improved capability and endurance requirements must be achieved. Military electronic hardware has been especially hard hit by manufacturers abandoning their low volume military qualified parts.

A tool that has been used to mitigate DMSMS since the 1980s is the procurement of commercial off-the-shelf (COTS) items across the board. One drawback of this approach is the inability of these electronics to withstand military environments. Ruggedization of commercial parts and systems is an attempt to have the available COTS electronics hardened to withstand the rigorous requirements of military use, while eliminating the need for very expensive custom designs. This technique has many other benefits as well. Increased performance and capability, increased availability, and drastically decreased costs can be achieved with modern COTS electronic products.

Electronics ruggedization addresses all aspects of the intended use of the devices.

- Replacement of electronic components that do not meet the temperature range or other environmental requirements.
- Addition of heating/cooling to expand the temperature capabilities.
- Addition of any necessary vibration isolation or dampening to component packaging.
- Selection and application of conformal coating to circuit boards for moisture, salt spray, and wind driven rain protection.
- Conversion to ruggedized electrical and fluid connectors.
- Additional circuitry, if needed.
- Redesign of the chassis and housings with EMI considerations, including radiated and conductive emissions and susceptibility.

Some product specifications include a boiler plate set of military specifications that may not be appropriate for the intended platform and should be more closely scrutinized. COTS design and ruggedization efforts cannot address some of the environmental EMI/RFI extremes. A well developed Performance Specification should be generated and approved, guided by the constraints of the desired unit and its intended use before the design is realized.

The EMPF has recently completed a Navy project for ruggedizing an advanced acoustic hailing system.[2] It is now being tested before deployment with the fleet. For more information about the complete design and manufacturing services for COTS development available at the EMPF, contact Ken Friedman, at 610.362.1200, extension 279 or via email at kfriedman@aciusa.org.

References

[1] DOD Supply Chain Materiel Management Regulation, DoD 4140.1-R (2003).

[2] Verdi, Fred. "Ruggedization of COTS Technology." *Empfasis* (Oct. 2008): 1.

John Doyle | Engineering Manager

Mechanical Drop Shock Testing

Accurate impact testing is a key component to establishing that a product is not only reliable, but durable in an end-use environment. The EMPF has recently tested a high-g circuit board to demonstrate component durability and ruggedization for guided munitions. The Lansmont Model 23 Shock Test System customized with a Dual Mass Shock Amplifier was used for this testing (Figure 3-1).

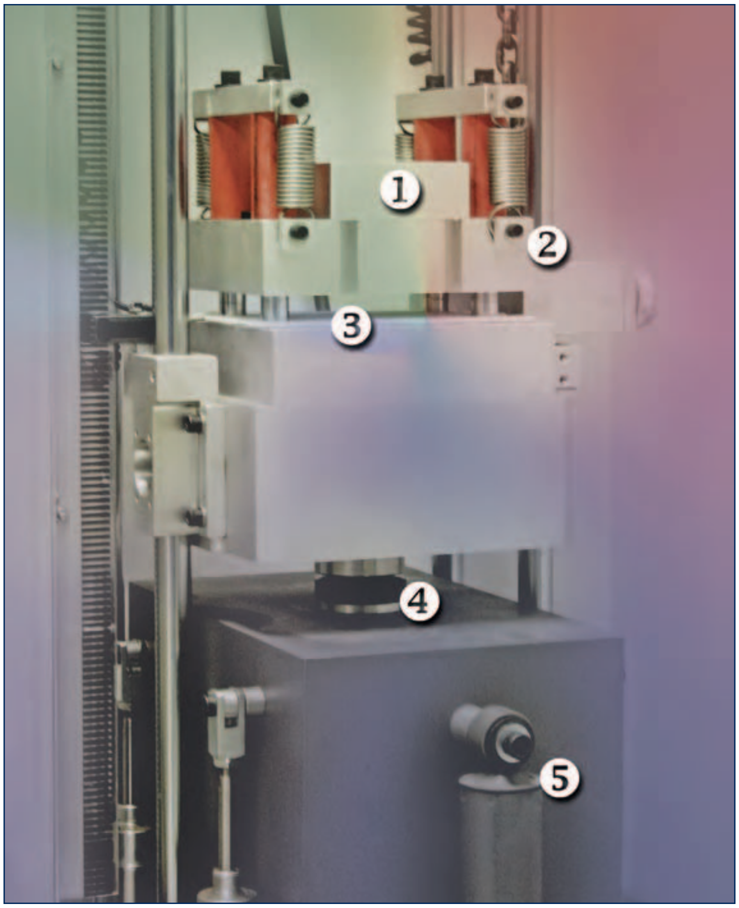

Figure 3-1: Lansmont Model 23 Drop Shock tester at the EMPF. Drop shock tester components: 1. sample mounting fixture, 2. dual mass shock amplifier, 3. cushion test surface, 4. shock pulse programmer, and 5. floating seismic reaction mass.

Test fixtures were custom designed to mount a circular circuit board consisting of daisy chained electrical devices encapsulated within a 2" housing (Figure 3-2). Shock forces can be achieved up to 25,000 g with this equipment. Before and after testing, electrical and physical connectivity of the test vehicle was assessed using electrical resistance path measurements and x-ray imaging. A change in resistance within the electrical path indicates partial failure in at least one component in the chain, at which point individual segments of the board can be isolated to determine the source of the failure.

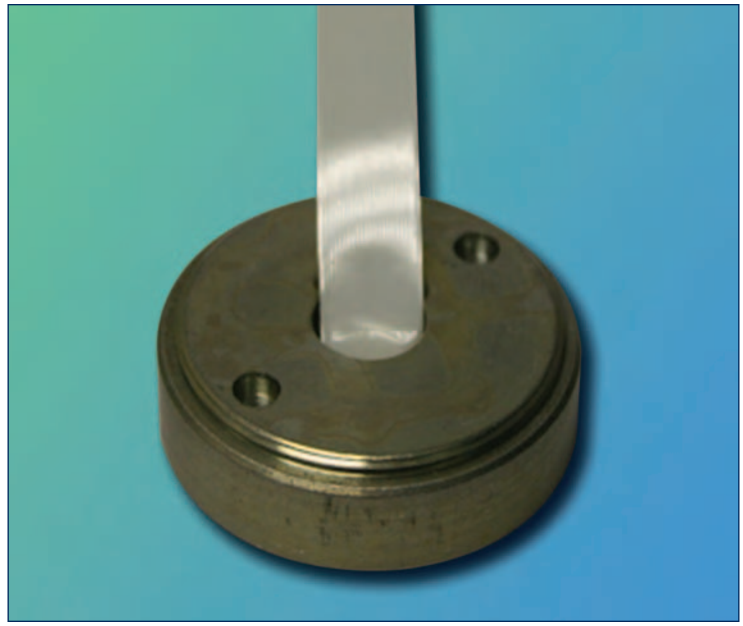

Figure 3-2: Fixture containing encapsulated test circuit board.

The amplitude and duration of the shock pulse waveform is optimized through adjustment of cushioning pads and the braking mechanism of the system. This calibration, along with data capture triggering, is critical for successful testing, particularly for the potentially destructive sample testing at high g values. Cushioning pads of a variety of thickness and hardness values are used to effectively dampen the impact, with the goal of optimizing the time duration of peak impact as well as reduce additional oscillation intensity.

Captured event data is transmitted to the Test Partner 3 data acquisition system where a detailed shock response spectrum can be produced. A result from this testing for a sample at 15,000 g is shown in Figure 3-3.

A piezoelectric accelerometer is employed to accurately measure acceleration forces for events as short as 0.25 milliseconds in duration. As shown in Figure 3-4, the accelerometer consists of an embedded piezoelectric crystal fixed in position with a rigid base structure and a calibrated seismic load mass. During an acceleration event, the seismic mass imposes a force on the crystal following Newton's second law of motion (Force = mass * acceleration). Through the piezoelectric effect, the crystal responds to the increased force with an increased voltage proportional to the acceleration experienced.

Custom fixturing can be designed to position test vehicles of a variety of sizes within a 9" x 9" footprint and along all three axes of orientation. In addition to performing a wide variety of programmable shock tests, the system can also perform materials impact evaluation (cushion testing) by dropping a load mass onto a fixed stationary object.

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Tech Tips: Die Attach Dispensing Methods

Die attach material selection and process implementation play crucial roles in any microelectronic assembly. The chosen attach methods ultimately affect die stress, functionality, thermal management, and reliability of the assembly. Die attach applications are designed to optimize mechanical attachment of the die to the substrate, to create a thermal path from the die to the substrate, and to create an electrical path for a ground plane connection. Some of the more commonly used die attach materials in the microelectronics industry today are epoxies, polyimides, thermoplastics, silicones, solders, and special low outgassing, low stress, anisotropic adhesives.

Most fluid adhesives exhibit characteristics which adversely affect the dispensing process.

- Thixotropy
- Viscosity (5,000 cps to 100,000 cps; sensitive to temperature and moisture)
- Tailing

Adhesive selection is very application specific and dependent on factors listed in Table 4-1.

The following are the manufacturing process steps to attach a die to the substrate.

- The die attach adhesive is dispensed on the die pad in a pattern to optimize attachment material coverage between the backside of the die and the substrate.
- The die is placed on the substrate with a pick and place machine. As the die is placed, the adhesive spreads to cover the die attach pad.
- The adhesive is cured, typically with heat.
- In wire bonded applications, encapsulation and sealing takes place to complete the assembly process.

The most common systems used in dispensing adhesives use a time-pressure dispensing valve, auger pump, positive displacement pump, or a jetting valve. Each technique has its unique advantages and disadvantages.

Time-Pressure Dispensing Valve: The time-pressure dispensing valve (Figure 4-1) consists of a syringe containing adhesive which is directly attached to the dispensing tip. Adhesive is fed from the syringe using pressure in a time-controlled manner. Pressure is removed to stop material flow. Fluid flow is proportional to the amount and duration of the applied pressure. Since the air pressure is kept constant over time, as the syringe is emptied, dot sizes decrease because the plunger does not advance as far with each air shot. This variability can be adjusted by increasing the air shot size, but is often operator-dependent and can lower throughput. Time-pressure systems are the most economical dispensing solutions, but have a lot of variation in their results, and are limited in the minimum dot size they can produce.

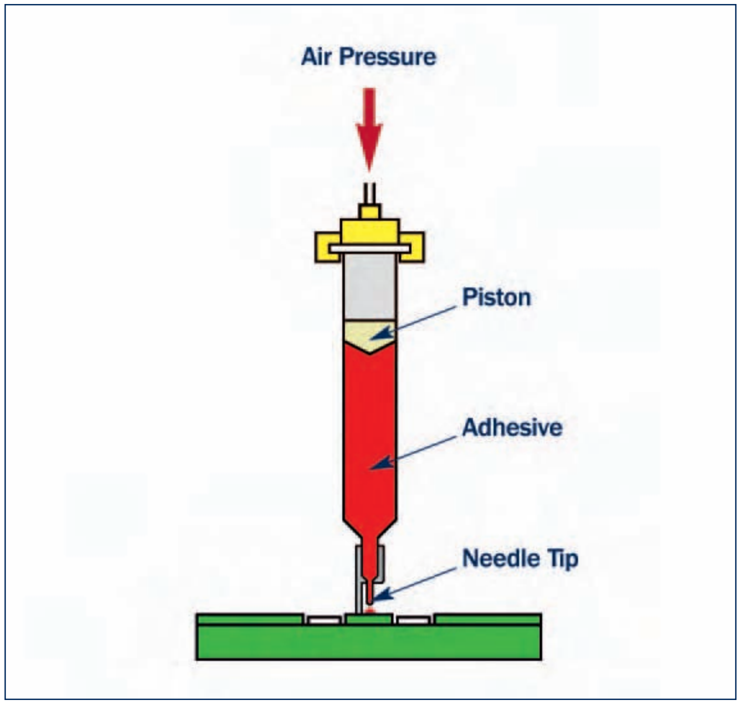

Figure 4-1: Time-Pressure Valve. Courtesy of EFD, Inc.

Dispenser Unit	Dispensing Parameters	Adhesive	Production Area	Training
X, Y, Z gantries	Pressure	Viscosity thixotrophy	Dust and dirt	Knowledge
Nozzle type	Time	Thermal conductivity	Air circulation	Awareness
Nozzle temperature	Standoff	Filler type	Temperature fluctuation	Authority
Vision system	Auger rotation	Cure schedule	Humidity control	Safety
Dispensing repeatability	Temperature	Pot life		
		Shelf life		

Table 4-1: Factors influencing adhesive selection.

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Manufacturer's Corner: FocalSpot, Inc.

Component packages continue to evolve into more complex designs, including ball grid arrays (BGAs) and surface mount technologies (SMTs). Cutting-edge equipment, capable of handling the removal and rework of these designs, is critical to electronics manufacturing production. Even the best rework stations currently available have their own nuances and intricacies associated with their use. The EMPF has an easy to use and very intuitive machine manufactured by DEN-ON Instruments Corporation of Japan and distributed by FocalSpot, Inc. The RD-500 rework systems are semi-automated, single axis placement and reflow stations for BGA/SMT rework. The RD series uses a high-performance three-point heating system and advanced computer control technology, designed for safe lead free and eutectic rework applications. Available in two models, the RD-500 series features a three-stage heating system that produces up to 3kW overall thermal output, sufficient thermal capacity and control to execute precise profiles on small to large sized printed circuit boards (PCBs) up to 20" x 24".

Figure 5-1: The RD-500II.

The capabilities of the rework station allow for some of the more difficult to profile packages, such as metal shielded, ceramic, heat sink plates, plastic column BGAs and even flip chip packages. These unique profiles are obtained by the localized top and bottom hot gas heaters and the bottom area array infra-red (IR) heating system. Safe and uniform heating is provided throughout the board. The high-resolution, digital split image optics provide quick and easy parts placement, accurate to within +/-0.00098" (+/-0.025mm). This is very important for your smaller package sizes such as 0402s and 0805. Additionally, the low air flow design eliminates the need for variable flow rate adjustments. Finally, the RD-500 series features automated pick and place with feedback control of the part placement force for more accurate part placement after rework.

With only a few hours of training, an operator can gain proficiency using the onboard assisted software. Some of the software enhancements include automated profiling, job and component process parameters storage and recall, and complete process data logging and file storage.

FocalSpot, Inc. is recognized as a leader in the design and manufacture of affordable high-quality x-ray inspection, and is the distributor for DEN-ON RD-500 Series BGA/SMT Rework Stations in North/South America, Canada and Mexico.

For more information on the DEN-ON RD-500 series rework station from FocalSpot or to schedule a demonstration, please contact the EAB Coordinator, Ken Friedman, at 610.362.1200, extension 279 or via email at kfriedman@aciusa.org.

Ken Friedman | EAB Coordinator

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Reliability Concepts

Reliability is defined as the probability that a component part, equipment, or system will satisfactorily perform its intended function under given circumstances (such as environmental conditions, operating time, frequency and thoroughness of maintenance for a specified period of time). Predicting reliability with some degree of confidence is dependent on correctly defining a number of parameters. For example, choosing the type of distribution that matches the data is of primary importance for accurate results. Individual component failure rates must be based on a large enough population to reflect current normal usages. There are also empirical considerations, such as the slope of the failure rate, calculating the activation energy, and determining environmental factors (such as temperature, humidity and vibration). Finally, there are electrical stressors in electronic assemblies such as voltage and current.

Reliability engineering can appear somewhat abstract in that it involves statistics; yet it is engineering in its most practical form. At the EMPF, we are often asked to help our valued partners determine that the proper design performs its intended mission. Product reliability is seen as a testament to the robustness of the design as well as the integrity of the quality and manufacturing commitments of an organization.

The Bathtub Curve

The lifetime of a population of units can be divided into three distinct periods. Figure 6-1 shows the reliability "bathtub curve" which describes the cradle to grave instantaneous failure rates vs. time. The initial steep slope from the start to where the curve begins to flatten, is the early life period or infant mortality period. This period is characterized by a decreasing failure rate that occurs during the early life of a population of units. The weaker units fail leaving a population that is more robust. The next period, the flat portion of the graph, is called the useful life period. Failures occur randomly, but at a nearly constant rate. The third period begins at the point where the slope begins to increase and extends to the end of the graph. This is the wearout period when units become old and begin to fail at an increasing rate.

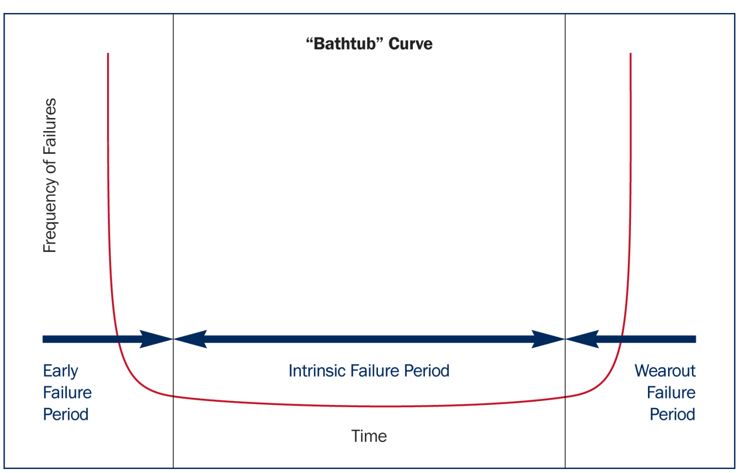

Figure 6-1: Reliability Bathtub Curve.

Early Life Period

Some of the design techniques the EMPF utilizes to ensure reliability include: burn-in (to stress devices under constant operating conditions); power cycling (to stress devices under the surges of turn-on and turn-off); temperature cycling (to mechanically and electrically stress devices over the temperature extremes); vibration; testing at the thermal destruct limits; and highly accelerated stress and life testing. In order to mitigate these risks in a product line, the manufacturer may choose to consume some of the early useful life of an assembly by stress screening. This technique allows the resulting population to begin its operating life somewhere closer to the flat portion of the bathtub curve instead of at the initial peak. The amount of screening needed for acceptable quality is a function of the process grade as well as history.

Useful Life Period

As the product matures, the weaker units die off, the failure rate becomes nearly constant, and modules have entered what is considered the normal life period. This period is characterized by a relatively constant failure rate. It is difficult to predict which failure mode will be manifested, but the rate of failure is predictable. The length of this period is also referred to as the system life of a product or component. It is during this period of time that the lowest failure rate occurs. The useful life period is the most common time frame for making reliability predictions. The failure rates calculated from MIL-HDBK-217 and Telcordia-332 apply only to this period.

Wearout Period

As components begin to fatigue or wearout, failures occur at increasing rates. Wearout in electronics assemblies is usually caused by the breakdown of electrical components that are subject to physical wear and electrical and thermal stress. It is this area of the graph that the mean time between failures (MTBFs) or failures in time rates (FIT - number of failure per billion device-hours) calculated in the useful life period no longer apply. A product with a MTBF of 10 years can still exhibit wearout in two years. No parts count method can predict the time to wearout of components. Electronics in general are often designed so that the useful life extends past the design life. This way wearout should never occur during the useful life of a module. For example, most electronics are obsolete within 20 years; MTBFs could extend 35 years or longer.

Weibull Analysis

The Weibull distribution is a very flexible life distribution model that can be used to characterize failure distributions in all three phases of the bathtub curve. The basic Weibull distribution has two parameters, a shape parameter, often termed beta (β), and a scale parameter, often termed eta (η). The scale parameter, η, determines when, in time, a given portion of the population will fail, i.e. 63.2%. The shape parameter, β, is the key feature of the Weibull distribution that enables it to be applied to

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SMT Component Reliability for RF Applications

(continued from page 1)

ROL0). The board layout was programmed into an SMT pick and place machine so the QFN and 0402 components could be placed accurately. A double reflow process was used since the CCA has components on both sides. All flux residue was removed using an inline cleaner to meet IPC-A-610 Class 3 requirements for circuit card assemblies.

Accelerated Testing Plans

Component reliability was tested using accelerated temperature cycling based on JEDEC Standard JESD22-A104. The assemblies cycled between +85°C to -40°C for 1000 cycles of 91 minutes each. Breaks for RF testing occurred at 100, 200, 400, and 1000 cycles to allow more resolution into the possibility of early thermal failures.

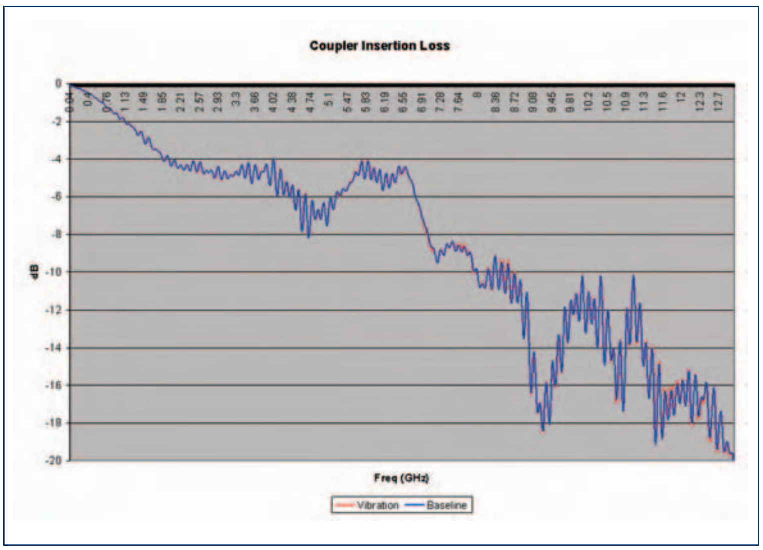

Figure 1-2: SMT Coupler X Band insertion loss before and after vibration testing.

Vibration testing was also performed to simulate the stresses of motion on the components over the life of the assembly. The three axes vibration testing was performed for two hours at frequencies from 4Hz to 50Hz per MIL-STD-167 Type 1. The test vehicles were RF tested prior to being sent for vibration and then RF tested again on their return to the EMPF.

Thirty test vehicles were assembled using the EMPF's SMT equipment. Prior to thermal cycling and vibration testing, each of the RF paths on all of the CCAs were visually inspected and swept for Transmission Loss (S21) and Insertion Loss (S11) to gather baseline data. An Anritsu Spectrum Analyzer was used and data was gathered from 40MHz to 20GHz.

Fifteen CCAs were sent for thermal cycling and fifteen were sent for vibration testing. After vibration testing, there was no evidence of cracked solder joints or other evidence of stresses between the devices and the board. The RF paths on each of the fifteen CCAs were swept and data showed no significant degradation in the performance of the devices or paths. Figure 1-2 shows the data for the coupler direct path baseline versus post-vibration test.

Fifteen CCAs were run through 1000 thermal cycles with visual inspection and RF testing performed at established break points. Again, no evidence of damage was apparent on the visual inspections and no significant degradation in performance was apparent on any of the CCAs after RF testing. Figure 1-3 shows the performance before thermal cycling and at each of the break points for the coupler direct path.

Report Summary

The analysis of SMT components in high reliability RF circuit card assemblies exposed to thermal cycling and vibration testing, showed no significant degradation of performance. Visual inspection of the components and the solder joints showed no physical damage and

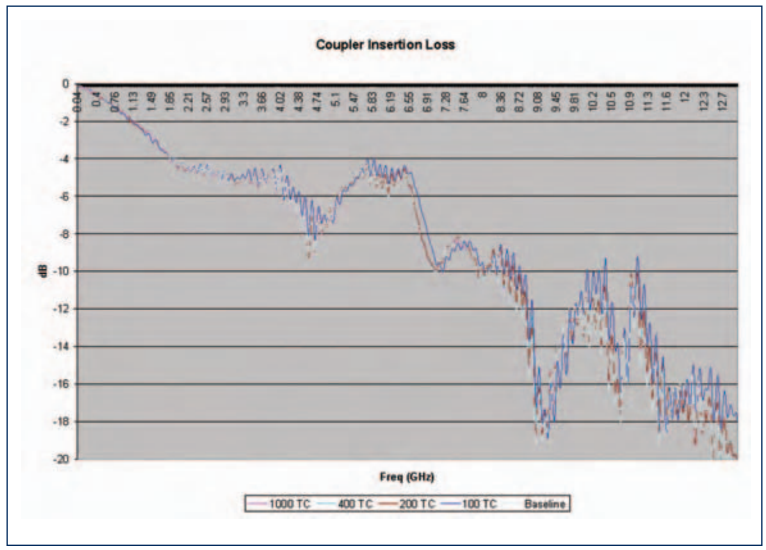

Figure 1-3: SMT Coupler X Band insertion loss before and after thermal cycling.

Figures 1-2 and 1-3 indicate that there is almost no degradation in performance through the accelerated life tests. Although the figures shown are for one specific device through the tests, all other SMT components performed as well.

Thermal cycling and vibration testing are among many of the analytical services offered at the EMPF, as well as component engineering and design services. For information and assistance with designing experiments to verify the integrity of electronic assemblies for military applications, contact Ken Friedman, at 610.362.1200, extension 279 or via email at kfriedman@aciusa.org.

Walt Barger | Senior Applications Engineer

Mechanical Drop Shock Testing

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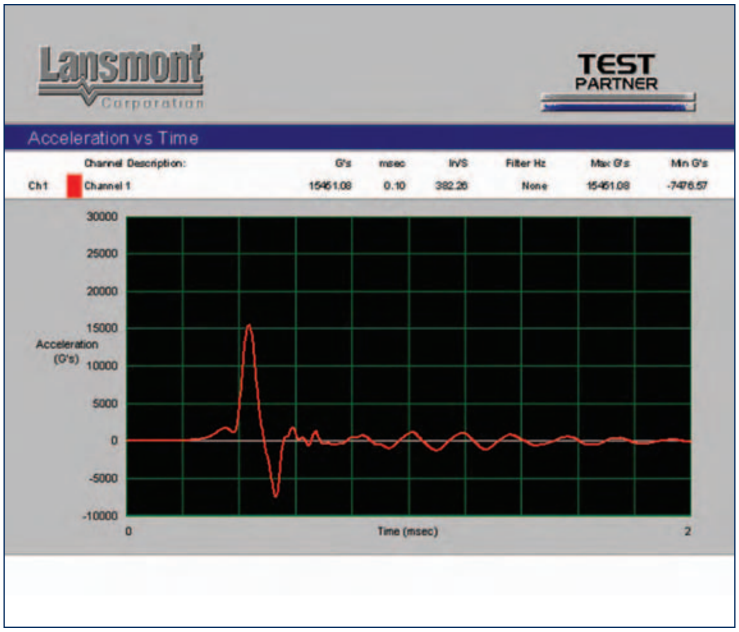

Figure 3-3: Data output for test sample experiencing 15,000 g.

To complement the mechanical drop shock testing, the EMPF also offers vibration testing using a Labworks vibration table. Shock and vibration testing can be combined with thermal cycling or thermal shock, Temperature Humidity Bias (THB) Testing, Highly Accelerated Stress Testing (HAST), salt fog, high temperature storage, or other environmental testing. For more information on shock or other reliability testing, please contact Ken Friedman, at 610.362.1200, extension 279 or via email at kfriedman@aciusa.org.

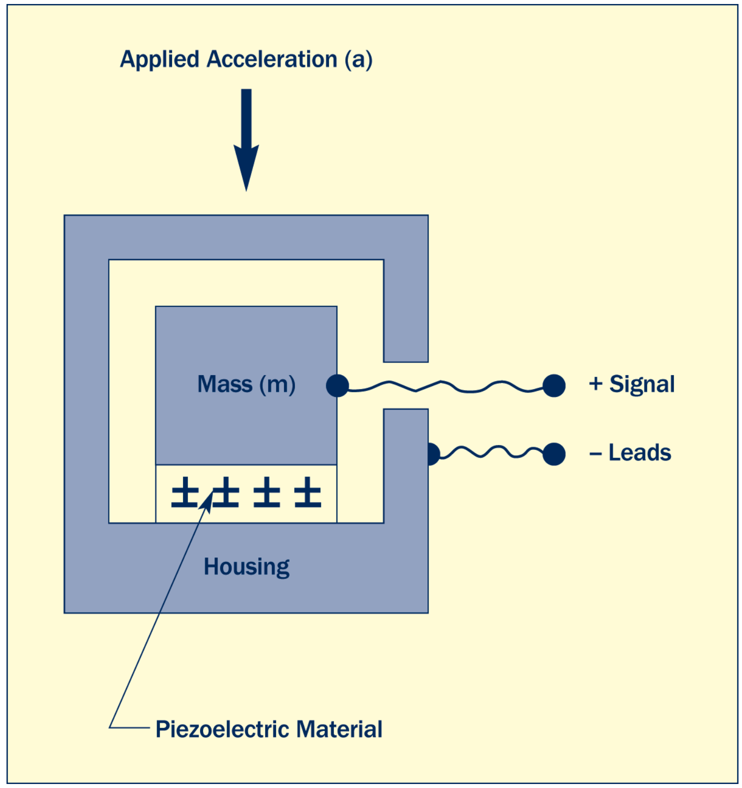

Figure 3-4: Theoretical schematic diagram of a piezoelectric accelerometer. Courtesy of PCB Piezotronics, Inc.

Dan Perez | R&D Engineer

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Tech Tips: Die Attach Dispensing Methods

(continued from page 4)

Auger Pump: Rotary auger pumps (Figure 4-2) use an Archimedean screw turning in a cartridge to push the material through the pump. In some cases, the pump uses an electromagnetic clutch to engage and disengage the constant-speed DC screw motor. Low-pressure air maintains a steady flow of the material into the pump. A precision-controlled auger pump is programmable, and uses a DC servo motor with an encoder to precisely control rotation. A programmed dispense signal provides a direct and specific point-to-point indexed rotation of the auger while regulating speed, thus precisely controlling the quantity dispensed. When auger pumps are used to dispense adhesives with fillers, filler size and properties should be taken into consideration. If the filler is abrasive, suitable auger screw material like tungsten carbide should be selected. Needle size and auger screw clearance should be twice the filler size for easy flow of the adhesive. If this size is too small, filler material will clog the needle or the auger resulting in inconsistent dispensing.

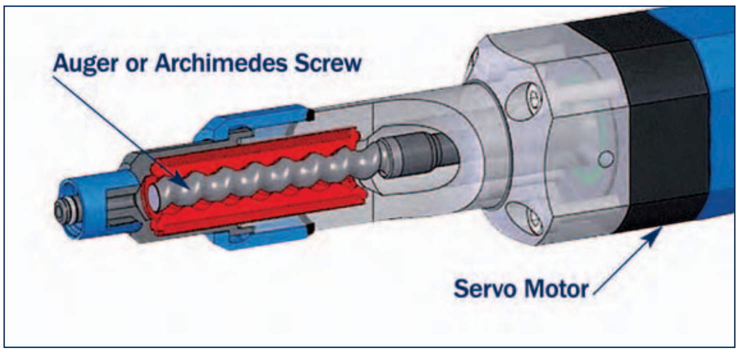

Figure 4-2: Auger Pump. Courtesy of Fluid Research Corp.

Positive Displacement Pump: Positive displacement pumps (Figure 4-3) use a piston to force material through a needle. The piston motion inside the dispensing system is controlled by a DC servo motor with precision encoder. The displacement of the piston in the chamber results in an equivalent positive displacement of fluid through the pump. The deposition time is extremely fast and is solely dependent on the piston size and the length of piston stroke inside the chamber. A change in viscosity does not affect the amount of material dispensed through the pump. If the piston is not seated well, adhesive leaks through the sides of the chamber. Constant pressure is critical for filling the chamber; a drop in pressure results in an insufficient amount of adhesive in the chamber resulting in a smaller amount of material being dispensed. Higher pressures may lead to adhesive leaking.

Jetting Valve: Jet dispensing (Figure 4-4) – also called non-contact dispensing – provides the highest speed, delivering adhesive dots from a height between 1mm and 3mm above the board. In addition, it minimizes problems with adhesive tailing. Different sized dots can be applied by simply programming the valve to jet multiple shots into the same location. This allows tight process control, better repeatability, and better dot consistency.

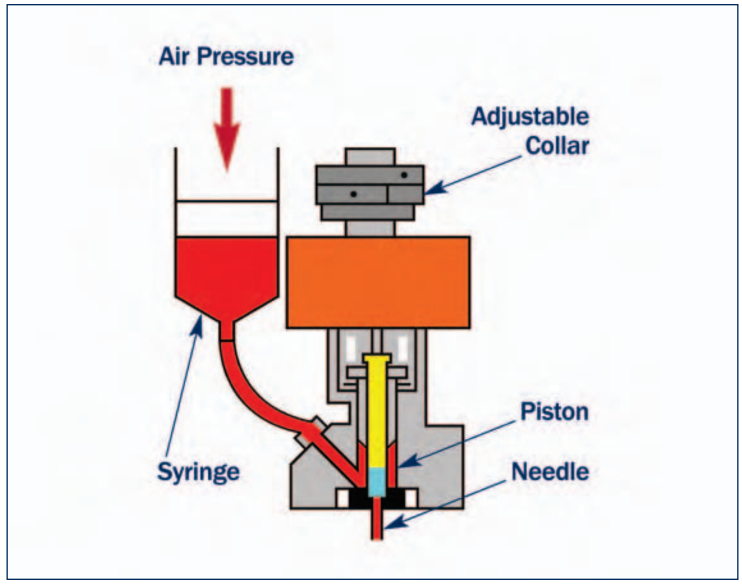

Figure 4-3: Positive Displacement Pump. Courtesy of Universal Instruments.

- Eliminates Z-axis motion during dispensing.
- Positive shutoff prevents tailing.
- Dispensing speeds as high as 1000 dots/min.
- Fluid stream can be placed in areas where needle will not fit allowing tighter spacing.
- Reduced chances of damaging die.

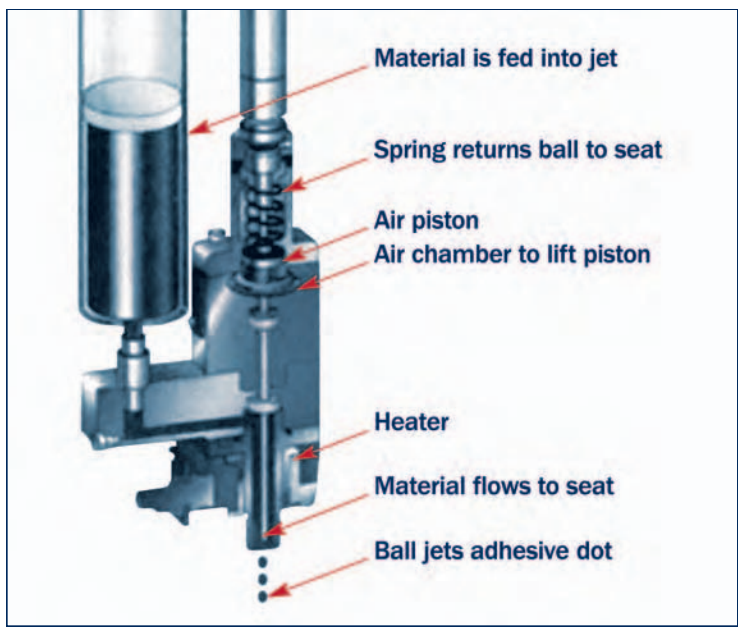

Figure 4-4: Jetting Valve. Courtesy of Asymtek.

continued on page 10

Tech Tips: Die Attach Dispensing Methods

(continued from page 9)

Advantages			
Time/Pressure Valve	**Auger Pump**	**Positive Displacement Pump**	**Jetting Pump**
Low maintenance.	Used for filled and unfilled adhesives.	Used for filled and unfilled adhesives.	Used for filled and unfilled adhesives.
Low cost. Minimal operator training required.	Closed loop system guarantees accurate adhesive dispensing.	Adhesive flow rates of 5000mg/sec with 1% accuracy can be dispensed.	Very repeatable dots/line. Can dispense wide viscosity range without any process issues.
Quick change over.	Cartridge change over is quick and easy.	Easy to clean.	Relatively easy to clean. Does not use needle tips.
Used for large die application and low production volume.	Very good for small die attach application.	Application range from very large BGA to small flip chip attachment.	Application which requires non contact Z, no space for needle to dispense adhesive, very high throughput.
0.01 inch minimum dot and line size can be dispensed.	Useful to dispense very small dots 0.006 inch very accurately.	0.008 inch dot or line size can be dispensed accurately.	Useful to dispense very small dots 0.006 inch very accurately.
Disadvantages			
Time/Pressure Valve	**Auger Pump**	**Positive Displacement Pump**	**Jetting Pump**
Need constant adjustment of timing/pressure.	Special operator training required to use the system.	Special operator training required to use the system.	Special operator training required to use the system.
Not useful for small dot application.	Expensive, need extra auger cartridge to quickly change over.	Expensive, pump is available in fully automated dispensing system.	Very expensive.
Not useful for solder paste and high viscosity adhesives.	Cleaning takes time and training.	Quick change over not possible without proper cleaning.	
	Need special auger cartridge for abrasive fillers as they will wear the auger screw.		

Table 4-2: Advantages and disadvantages of dispensing methods.

The advantages and disadvantages of each dispensing method are shown in Table 4-2.

The desirable qualities of cured adhesive after die is placed are:

- A thin bond line to reduce electrical and thermal resistance.
- Cured adhesive after the die is placed should not squeeze out and touch the adjacent bond pads. This will create an electrical short if the adhesive used is electrically conductive. Subsequent wire bonding operation will be affected if adhesive is smeared on the bonding pads.
- Void free to maximize strength, thermal conductivity, and electrical conductivity.

A thorough design and process review, including definition of production needs, should be considered before selecting a suitable dispensing system for a given application.

For more information on the selection of an appropriate dispensing system for a specific application, or any dispensing issues or concerns, please contact the EMPF Helpline by phone at 610.362.1320 or visit the website at www.empf.org.

Anand Bhavankar | Senior R&D Engineer

Reliability Concepts

(continued from page 6)

any phase of the bathtub curve. A β<1 models a failure rate that decreases with time, as in the infant mortality period. A β=1 models a constant failure rate, as in the normal life period. And a β>1 models an increasing failure rate, as during wear-out. There are several ways to view this distribution, including probability plots, survival plots and failure rate versus time plots. The bathtub curve is a failure rate vs. time plot. The Weibull distribution is given by Equation 6-1:

$$f(\mathrm{T}) = \left(\frac{\beta}{\eta}\right)\left(\frac{\mathrm{T}}{\eta}\right)^{(\beta\text{-}1)} e^{-\left(\frac{\mathrm{T}}{\eta}\right)^{\beta}}$$

Equation 6-1: Weibull distribution equation.

The results of various βs on the Weibull analysis can be seen in Figure 6-2. Notice how, if all curves are combined, the resultant graph is similar to a bathtub curve.

The EMPF not only uses Wiebull analysis routinely but also teaches the process as a part of our electronics manufacturing training. This distribution, for example, allows modeling to be done with a minimal amount of error. At the EMPF we engage our students with practical applications on how to utilize the various forms of reliability modeling.

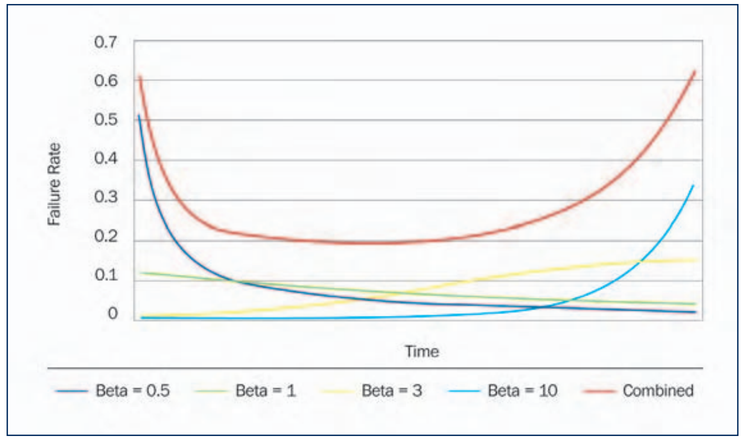

Figure 6-2: Results of various βs on the Weibull analysis.

For more information on engineering and other training classes, please contact Ken Friedman at 610.362.1200, extension 279 or via email at kfriedman@aciusa.org.

Michael Barger | Senior Materials Engineer

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CONTACT THE REGISTRAR VIA:

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Electronics Manufacturing

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May 3-7
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IPC 7711/7721
Call for Availability

IPC/WHMA-A-620A
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April 19-21
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December 20-22

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CIT Certification
January 15
February 26
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October 18-22
December 6-10

IPC J-STD-001
CIT Recertification
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April 14-15
May 26-27
July 14-15
August 25-26
October 6-7
November 17-18
December 15-16

IPC A-610
CIT Certification
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April 19-22
June 14-17
August 16-19
October 11-14
December 6-9

IPC A-610
CIT Recertification
January 11-12
February 22-23
April 12-13
May 24-25
July 12-13
August 23-24
October 4-5
November 15-16
December 13-14

IPC A-600
CIT Certification
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March 22-24
June 21-23
September 7-9
November 29 - December 1

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